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Control of Red Spider and Powdery Mildew on Greenhouse Cucumbers

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Contribution from the
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Cedar Hill, Waltham

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Large losses in yield and quality of greenhouse cucumbers result from the attacks of red spider and powdery mildew and from failure to use effective control measures promptly and correctly. Satisfactory treatments for controlling these pests individually are now available but the materials which are used cannot be combined or applied closely following one another with safety. The incompatibility of these materials is a serious handicap to the successful control of these pests when both are present on the vines. This bulletin suggests the proper choice of materials for effective and safe control by a combination treatment, as well as methods of greenhouse management which tend to check the damage by red spider and powdery mildew.

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AGRICULTURAL EXPERIMENT STATION,
AMHERST, MASS.

CONTROL OF RED SPIDER AND POWDERY MILDEW ON GREENHOUSE CUCUMBERS[1]

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Introduction

The red spider[2], sometimes called the greenhouse mite, and powdery mildew[3] are common pests of greenhouse cucumbers in Massachusetts. Few growers in this state can boast that they have grown this crop for two successive seasons without suffering damage from one or both of them. In 1917 it was estimated by Vinal[4] that the red spider caused annual losses amounting to $150,000 in the Boston market gardening district alone. Powdery mildew is often equally serious and its presence at times has proved an important obstacle in the profitable production of greenhouse cucumbers. The presence of both pests on the vines at the same time is common and the need for a combined treatment is obvious. Likewise, a knowledge of the compatibility of insecticides and fungicides used in the greenhouse for combating these and other pests is extremely important to prevent injury to the vines.

Host Plants

The cucumber, especially when grown in the greenhouse, is one of the favorite host plants of both red spider and powdery mildew. Greenhouse tomatoes are also attacked by this mite although they are seldom seriously injured. The red spider also feeds on a great many greenhouse flowers, especially violets, carnations, chrysanthemums and sweet peas. The list of outdoor plants known to be infested by it includes about two hundred wild and cultivated plants ranging from arbor vitae to chickweed.

Cucumber powdery mildew occurs on squash, pumpkin, melon, and other cultivated plants of the gourd family as well as the wild balsam-apple and the bur cucumber. It is also definitely known to attack plantain and sunflower. The common powdery mildews on other plants such as lilac, rose and clover, although similar in general appearance, are different from cucumber powdery mildew and cannot live on plants of the gourd family.

Description and Growth

Effective control of plant pests demands not only the application of specific treatments but also the adaptation of those treatments to local and sometimes varied conditions. This can be satisfactorily accomplished only by a knowledge of the appearance, growth, and habits of the pest and an understanding of the conditions under which it thrives.

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1. The information in this bulletin is based on the results of experiments conducted by the writers at the Market Garden Field Station, Waltham and in commercial greenhouses in eastern Massachusetts.

2. *Tetranychus telarius* Linn. (Syn. *T. bimaculatus* Harvey). The red spider belongs to a group of Spiders called *Mites*.

3. *Erysiphe cichoraceaum* DC.

4. Vinal, Stuart C., The Greenhouse Red Spider Attacking Cucumbers and Methods for Its Control. Mass. Agr. Expt. Sta. Bul. 179, 1917.

Greenhouse red spiders live almost entirely on the under side of leaves where each female lays about 70 spherical, pearly white eggs (Plate I,a1) which are so small that they are scarcely visible to the naked eye. These eggs gradually turn to a dark straw color and in four or five days a round, colorless, six-legged spider larva hatches from each of them (Plate I,a2). After feeding for one to three days, the young red spider, now light green in color with bright carmine eyes, attaches itself to the leaf for a rest and transformation period. While in this condition it appears to be dead but in about 24 hours an eight-legged spider nymph emerges from the old skin and thereafter it always has eight legs. Following each of these molts, as they are called, it feeds ravenously and inflicts the greatest damage by piercing the leaf cells and sucking the green matter from them, thus causing the characteristic yellow or dead areas. Female spiders repeat this process of growth twice before the adult, about one-third the size of a pin head, develops (Plate I,a3). The adults are usually green or yellowish red in color but occasionally rusty red specimens are seen. The smaller, thinner, male red spiders have but two of these transformation periods.

As soon as the mites become established they spin silken webs over the parts of the leaf where they are feeding and in severe infestations these webs extend from leaf to leaf and to the supporting wires or trellises. The average time required for the growth of female red spiders from the laying of the egg to the development of the adult is eight to ten days and for the males seven to nine days. Reproduction is practically continuous in the greenhouse, and in the South at least seventeen generations in one year have been observed out-of-doors.

Cucumber powdery mildew is a parasitic fungus. Such a fungus is a simple plant, in some respects similar to green plants but differing largely in that it maintains a dependent existence as a parasite on green plants. The white powdery webs (plate I,b) on the leaves and young stems, which suggest the name, consist of a dense network of tiny threads from which arise simple stalks each bearing a chain of spores or reproductive bodies. Except for the short, swollen tubes or "suckers" which penetrate the surface cells of the leaf to attach the fungus and to absorb food and moisture, mildew grows entirely on the surface and all visible signs of it may readily be rubbed away with the fingers. When the spores are mature they are shed from the stalks, and drafts of air or slight disturbances to the vines free them from the leaves. Those that fall on cucumber or other host plants germinate under favorable conditions producing suckers and a dense thread-like web bearing a new supply of spores. The multiplication of the fungus in this manner causes a rapid spread of the disease. Mildew weakens or stunts the plants and a severe attack reduces the yield and quality of the fruit.

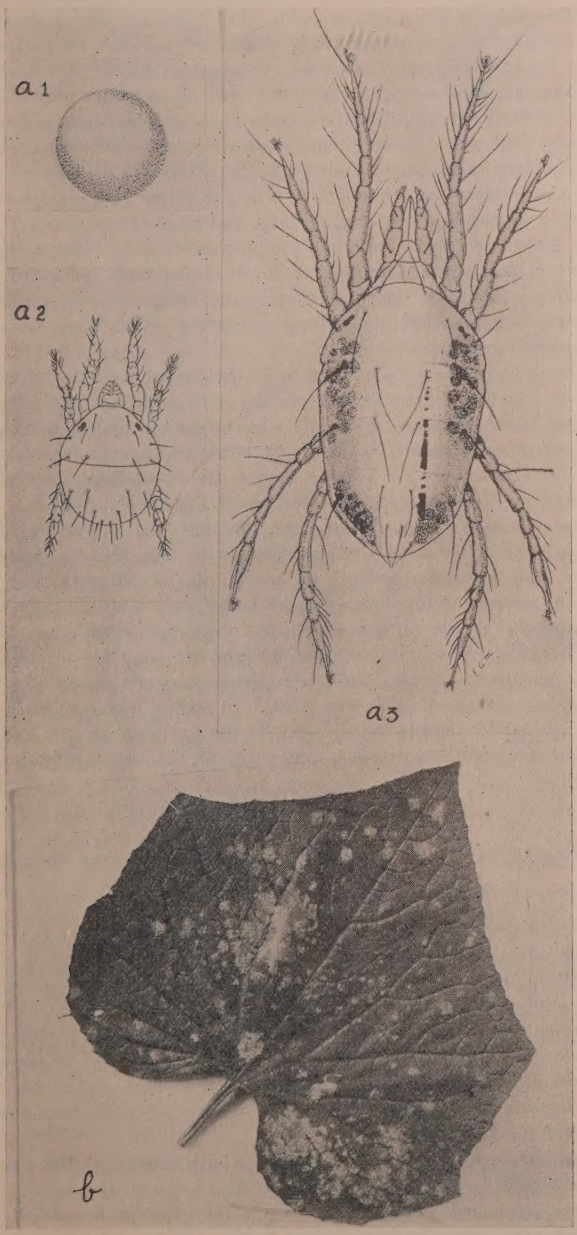
Most powdery mildews produce winter spores in small black capsules late in the season but very little is known of this stage of cucumber powdery mildew. It is believed, however, that the fungus lives through the winter out-of-doors in this form and also as mycelium or spawn. In the greenhouse the fungus survives from one crop of cucumbers to the next.

Cucumber powdery mildew should not be confused with the more serious downy mildew which forms a brown web on the under side of cucumber leaves causing yellowish spots and later dead leaves. This disease appears in the late summer and autumn months and because its attack is sudden and its spread rapid, it is much more dreaded by growers than powdery mildew.

PLATE 1.

a. Stages of the Red Spider *(Tetranychus telarius* Linn. syn. *T. bimaculatus* Harvey). (1) Egg. (2) Newly hatched larva having six eggs. (3) Adult female. All highly magnified. (After McGregor, Bulletin No. 416, U. S. Dept. of Agr.)

b. Powdery Mildew *(Erysiphe cichoracearum* DC.) on leaf of cucumber, showing characteristic white powdery growth. About one-half natural size.


a1
a2
a3
b

Favorable Conditions for Growth and Spread of the Pests.

Conditions suitable for growing greenhouse cucumbers are generally favorable for the growth and reproduction of the red spider. Its natural migration from leaf to leaf and from plant to plant in search for food, thus increasing the size of the original infested area, is normally very slow but in hot, dry weather when multiplication takes place rapidly, colonies will quickly outgrow the leaves on which they are feeding and spread to surrounding plants. Artificial dispersion resulting in the sudden appearance of isolated colonies, remote from the original infestation, is much more important. Workmen engaged in pruning, training, picking, and otherwise caring for the vines, carry the spiders on their tools and clothing from one plant to another and are the commonest agency responsible for the unnatural spread of this pest. In the summer, however, many of them gain entrance to the greenhouse by being blown through open ventilators or carried on clothing from infested out-door plants growing nearby.

When powdery mildew once appears in the greenhouse its spread may be rapid. The light spores are readily carried by currents of air. The workers become sprinkled with them, especially when brushing against mildewed vines, and are therefore a common means of spreading the fungus from one plant to another and from house to house. Spores from out-door hosts are also a common and important source of infection of the housed plants.

Spore germination and infection occur in damp air. The appearance of powdery mildew in the houses is associated with cool, dull, or damp weather when pipe heat is used sparingly or not at all. Powdery mildew may develop in any season of the year providing favorable moisture conditions prevail. Outbreaks of the fungus accompany improper watering practices and lack of attention to ventilation; drafts of cool or damp air through ventilators, doors, and broken glass; stuffy air pockets not adequately provided with ventilation; and lack of sufficient heat. In every instance moist air, not properly altered by ventilation or heat, is the basis of growth and development. Potted plants when grown under any of the above conditions become mildewed.

Control.

Repressive Measures for Red Spider and Powdery Mildew.

Between-crop Treatment of Greenhouses.

In order to grow healthy plants the greenhouse must be free from parasites which affect those plants before the new crop is set. This is true in the case of red spider when cucumbers or other host plants follow cucumbers but in the case of powdery mildew, only when cucumbers follow cucumbers, since this is the only host plant grown commercially under glass in Massachusetts. If the previous crop was attacked, between-crop-treatment is necessary and in any case it is advisable. By treating the greenhouse before the old vines are removed, the pests are killed without danger of spreading them beyond the effect of the treatment.

The commonest effective treatment is to burn sulfur at the rate of one-third of a pound for each 1000 cubic feet of space with the ventilators closed for at least 24 hours. The fumes from burning sulfur are deadly to plant and animal life. Some growers object to the practice of burning sulfur between crops because of the corroding action which the acid fumes of sulfur have on unprotected metal pipes, posts, and wires, and its bleaching action

on paint. It has been common experience that these objections hold only where repeated excessive quantities of sulfur are burned. Many experiments have shown that the fumes from burned sulfur kill all stages of the red spider but in spite of this fact many growers report negative results. These are undoubtedly due to leakage and to the ability of some of the mites to escape the fumes by crawling into cracks where they obtain a draft of fresh air. The practice, nevertheless, is considered worth while as a means of destroying parasites and safeguarding the next crop from a potential inside source of attack.

If the burned sulfur treatment is undesirable, fumigation with calcium cyanide at the rate of one-fourth to one-half pound per thousand cubic feet for 24 hours will kill all red spiders and insects but not mildew. The smaller dosage is sufficient in a gas tight compartment but most greenhouses require the larger amount. After watering freely to provide moisture for the rapid generation of the hydrocyanic acid gas, the calcium cyanide should be scattered evenly over the beds and walks. The fumes are very poisonous and breathing them must be avoided as much as possible. When using cyanide in a large house, it is well for two men to work together, one working toward each end from the center. This treatment is effective, easily applied, and requires no equipment.

When properly carried out, fumigation with melted and vaporized naphthalene rids the house of red spiders and insect pests more effectively than the burned sulfur treatment. The naphthalene crystals are melted and vaporized in shallow pans or dishes over a lamp or kerosene stove at the rate of 1 pound for each 1000 cubic feet. During this treatment, the temperature must be maintained continuously at about 75°F. A stove or lamp for each 10,000 cubic feet is desirable and the heat from the stoves should be regulated so that the melted naphthalene is vaporized without boiling. This fumigation must be continued for at least 48 hours and naphthalene should be added at regular intervals until the required amount is used. This treatment is used generally in England where special stoves for this purpose are manufactured. It requires special equipment and moderate attention. The naphthalene costs about 17 cents per pound and is about as expensive as cyanide in proportion.

The choice of these between-crop fumigation treatments depends largely on conditions. Only burned sulfur exerts fungicidal action, but cyanide and naphthalene are slightly more effective against red spider. Therefore two of the treatments may be advisable.

Hot water or steam treatments of the soil, practiced for controlling soil inhabiting pests in the greenhouse, will kill red spider and powdery mildew present on the treated soil but have no controlling effect elsewhere in the house. Soil sterilizing practices, therefore, should be preceded or followed by fumigation with one or more of the other suggested materials.

Growing Clean Plants

Frequent inspection of the young plants in the plant house is necessary to safeguard against an early infestation. If pests are present, the plants should be given the recommended control treatments immediately. Before the plants are set in the houses, they should again be carefully examined. When either red spiders or powdery mildew are found at this time, control measures should be applied before transplanting. Only pest-free plants should be set.

Precautionary Measures

When either red spider or powdery mildew is discovered on transplanted plants, the recommended control measures should be applied immediately. Since workmen are common means of carrying these pests, it is unwise for those who have come in contact with infested vines to enter other houses without first making every effort to rid their clothing and tools of any pests which may be on them. Picking baskets should be given careful attention. These precautions may appear impractical in commercial establishments but they will aid in reducing the spread and abundance of red spider and powdery mildew.

Mixed Crops in the Greenhouse

Host plants of powdery mildew other than cucumber are seldom grown in the greenhouse, but small lots of miscellaneous plants in benches and pots are often infested with red spider. The origin of serious red spider attacks on cucumbers has been traced to violets, carnations, and mint, and in one case infested chickweed was strongly suspected. Such plants should be examined at regular intervals and if infested, destroyed or treated.

Surrounding Vegetation

The ground immediately surrounding the greenhouse should be kept clean of vegetation or at least free from plants which harbor cucumber pests. It is unwise to grow plants commonly infested by red spider or powdery mildew close to a greenhouse cropped to cucumbers, as any pests present out-doors may be blown or carried by insects into the greenhouse.

Specific Measures for Red Spider Control

Partially Effective Treatments

Spraying and dusting have long been the principal methods of combating the red spider and probably more different materials have been used for this purpose without complete success than for any other greenhouse pest. These materials, if used thoroughly and frequently, when conditions are favorable for their use, will hold a light or moderate infestation in check but the control obtained from them is not permanent and eradication is impossible.

Some of these temporary remedies are washing with water, spraying with salt solution, flour paste, dissolved soap, nicotine, derris extract, pyrethrum extract, pine oil, lemon oil, linseed oil emulsion, miscible oil, and various combinations of these materials. Some check the development of the spiders by washing them from the plants; others stick them to the leaves; and many kill or injure the more susceptible stages of the pest. Some of them are injurious to foliage and none of them give safe and economical control of the red spider on greenhouse cucumbers. Derris extract, pyrethrum extract, lemon oil, and linseed oil emulsion are the best of these partially effective materials, yet each has several disadvantages.

Dusting or spraying with various compounds of sulfur has been used extensively in the past to combat the red spider both in the greenhouse and outside, but the effectiveness of sulfur is limited by its dependence on high temperatures. Sulfur sprays do not kill red spider eggs and have little effect on the transforming stages. Dusting is not effective because of the difficulty in placing the dust on the under side of the leaves where the spiders congregate.

Linseed oil emulsion, developed by Vinal[1], combined a toxic action with the ability to stick the spiders to the leaf when it dried. This spray has been used quite effectively to kill the active and transforming stages of this pest but it has little or no effect on the eggs, and frequently injures cucumber vines.

Highly Refined White Mineral Oil Emulsion

The most effective and satisfactory spraying material for the control of red spider on greenhouse cucumbers is a highly refined white mineral oil emulsion which contains no carbolic or cresylic compounds to aid in emulsification. Experiments with a spray of this type have consistently shown that 95 to 100 per cent of the spiders were killed by one application and that a large percentage of the eggs which were thoroughly wet failed to develop. Two thorough applications gave complete control. It was also observed that many newly-hatched spiders were killed by crawling through the oily spray residue several days after the applications. Many cucumber growers have used this emulsion successfully during the past year in eastern Massachusetts.

This highly refined white mineral oil emulsion is a white, shiny, salve-like material. It should be thinned with a little water before pouring into the sprayer. For spraying cucumbers, a one per cent dilution made by adding 1 gallon of the emulsion to 99 gallons of water, or 1¼ liquid ounces to 1 gallon, should be used. At this strength it does not injure healthy cucumber vines except when applied during temperatures of 95°F., or higher, when burning or a gradual hardening, and yellowing of the older leaves may result. Leaves badly injured by red spiders or other pests may develop this condition more quickly following the use of the emulsion, but this injury is much less than if the pests were not controlled. Cucumber vines have maintained normal growth and fruit production after ten applications of this spray at about weekly intervals without evidence of injury. During the summer the spray should be applied in the evening or during cloudy weather in order that it may dry before being subjected to bright sun and high temperatures. In the cooler seasons it can be used with safety at any time. If cucumber vines are sprayed twice before they are 7 to 8 feet high, little injury by the red spider will follow. In case later sprayings are necessary two applications about one week apart should be sufficient. If small isolated infestations are discovered before the mites have spread, two thorough sprayings of the infested and surrounding area should eradicate the pest and protect the remainder of the vines. Although this spray will control red spider on any plants, its use on other greenhouse plants is advisable only when trials have demonstrated that the plants are not injured. A white mineral oil emulsion can be prepared at home for immediate use but it is recommended that the commercial product now available on the market be used. This product is uniform in quality and the diluted spray costs from 1½ to 3 cents per gallon depending on the quantity purchased.

The spray is best applied as a fine mist which thoroughly wets the vines, especially the under side of the leaves. Knapsack, wheelbarrow, and compressed air sprayers can be used for small areas and young plants, but in spraying a large greenhouse, a power sprayer is desirable. The spray nozzles should be set at an angle of about 60 degrees to the rod.

[1]. *Loc. cit.*

Fumigation with Naphthalene

In the past, no fumigant has effectively controlled the red spider without injury to the plants. Recently, however, experiments both in Europe and this country have shown that three or four treatments with vaporized naphthalene at the rate of 1½ to 4 ounces of crystals to each 1000 cubic feet were very effective and safe for this purpose with high temperature and humidity. During these experiments, however, it was found that the fruits absorbed the odor and taste of the naphthalene. This almost entirely disappears after several hours in fresh air but the danger of selling tainted fruit to the consumer is considered so important that the treatment is not recommended to cucumber growers.

Specific Measures for Powdery Mildew

Greenhouse Management

The proper management of the greenhouse air as a means of avoiding attacks of powdery mildew should receive consideration. Healthy plants are never quite as healthy after they have been sprayed or dusted, although the detrimental effect of the materials applied is seldom realized. An atmosphere unfavorable for mildew infection and consistent with the best growth of the plants is the natural method of culture and should supersede the use of fungicides.

Moisture saturated air in the greenhouse is conducive to the development of mildew. The moisture content of the greenhouse air depends on the use of heat and ventilation and may be adjusted to prevent favorable conditions for infection. The relative humidity of the air can be accurately determined only from a hygrometer, a satisfactory and economical type of which is illustrated in Fig. 1. This instrument consists of a dry thermometer, wet thermometer, and glass tube of water for supplying the wet bulb with moisture. The relative humidity is determined by applying the thermometer readings to a simple table. When the air is saturated the temperature of both the wet and dry thermometers is the same. It is desirable to keep the relative humidity of the greenhouse air below 90 per cent. This can be done with heat, ventilation, or both. Side ventilation should not be used at night or during damp weather. If at such times ventilation is desired, it should be from the top and from the side on the top opposite the direction of the wind. Watering should be done on bright days before noon with ventilation and if the air is not sufficiently dry by night, heat should be used. Stuffy air conditions should be corrected by adequate ventilation. Vestibules at the entrances are helpful in preventing conditions favorable for infection of the plants at these places.

Dusting with Sulfur

Sulfur is the most effective fungicide for controlling mildew, and dusting is the most practical and economical method of application. Only sulfur of extreme fineness should be used. Some of the commercial sulfur dusts of this type sold in Massachusetts are Kolo dust, Grape Dust and Tricked Sulfur. The active principle in each of these materials is sulfur but its content varies. Non-dusting sulfur, such as is ordinarily used for burning, lacks the fluffy, powdery qualities of a fine dust, and should not be used for dusting purposes. The desirable grades of dust referred to in this bulletin are prepared especially for dusting plants and may be secured of dealers specializing in

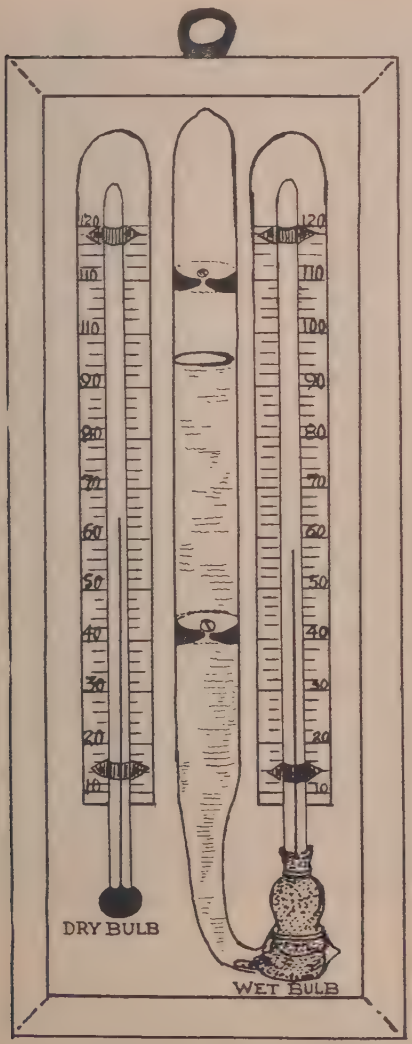


Fig. 1. A satisfactory type of hygrometer.

the sale of insecticides and fungicides. The choice of any of the materials mentioned should be governed by the retail cost.

The proper choice of equipment for dusting is important. The duster illustrated in Figure 2 has proved most satisfactory for greenhouse purposes. Its use among the plants is not hindered by wires, posts, trellises, or deep walks as is the use of the heavier dusters strapped to the body and provided with long extension tubes. This duster holds 2 quarts or 4 pounds of dust so that the load carried is very light. The dust is expelled by pushing a plunger

Fig. 2. Type of duster and method of operation recommended for applying sulfur dust to greenhouse cucumbers.

forward with one hand while the other holds the handle supporting the duster.

Quiet air should prevail in the greenhouse to permit the dust to settle. This is obtained by closing all ventilators for 30 to 45 minutes previous to dusting. If closing is likely to cause unfavorable growing temperatures, dusting should be done in the evening or morning when the ventilators may be closed for longer periods thus allowing a more complete settling of the dust.

When dusting, the course of travel should depend on the construction of the greenhouse. In houses 40 feet wide with walks through the center and around the sides, all of the dusting should be done from the walks (Fig. 3,a); in houses wider than 25 feet and provided only with central walk, every 3 to 5 rows should be entered for about one-half the distance (Fig. 3,b). If only outside walks are present the course of travel should be between every

3 to 5 rows of plants (Fig. 3,c). At every 5 to 10 walking paces the extension tube of the duster should be raised overhead. One to two pushes of the plunger with the duster in an obliquely vertical position will cover about 500 square feet with dust. If mildew is encountered on the lower sheltered leaves, light horizontal discharges of dust should be made but the nozzle should never be placed directly upon the leaves. The same general directions apply to a house of young cucumbers. The dust should be directed into the air above the plants and allowed to settle on the foliage. In exercising these precautions the danger of sulfur injury to the vines is reduced to a minimum and there is no waste of material.

The practice of using more sulfur dust than is necessary to control mildew has been responsible for injury. The results of numerous experiments have shown excellent control in 40x280 foot houses from one application with as little as 5 to 6 pounds of dust. More than this amount should not be used even if mildew is generally present in the house. Proportionately smaller

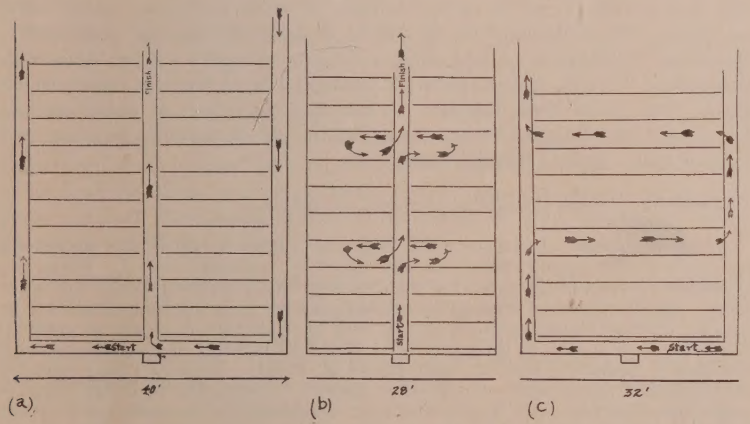


Fig. 3. Courses of travel with duster in differently constructed greenhouses.

quantities should be used in smaller houses. The reasons for suggesting these precautions are (1) powdery mildew is very susceptible to extremely small doses of sulfur under warm air conditions; (2) under similar conditions excessive doses of sulfur cause either burning, hardening or stunting of the leaves; (3) sulfur dusting materials are highly concentrated.

The effectiveness of sulfur in controlling mildew is dependent upon sulfur gas which is generated above 70°F., and in increasing amounts with higher temperatures. By proper management of the ventilators, temperatures favorable for the liberal production of gas may be obtained in bright weather. The closing of the ventilators also offers a means of concentrating the gas in the greenhouse. Since the gas given off from sulfur is fungicidal, contact of the sulfur particles with mildew is not necessary, to obtain control. After dusting, the ventilators should be managed, if necessary, to provide temperatures of at least 80 to 85°F., for a few hours each day until the fungus has been eradicated.

Spraying—

Below the temperature of 70°F. and in prevailing dull weather, sulfur dusting materials do not give control. Mildew in contact with sulfur particles is destroyed but that on the lower and sheltered parts of leaves is not affected. When such weather conditions render sulfur dust of no value, spraying must be resorted to for controlling the fungus.

Both copper and sulfur spraying materials kill mildew but they are injurious to foliage at strengths ordinarily used on other plants. At weak strengths they impart no harmful effect to the foliage and control mildew. In the case of copper sprays, complete wetting of the foliage is important since the action of the spray is exerted only when the fungus is wetted. After the spray has dried, the copper residue offers little, if any, protection from subsequent infection. Frequent treatments with copper sprays may be necessary to maintain control. Freshly prepared Bordeaux mixture of the formula 1-1-50 or commercial copper preparations diluted to contain an equivalent amount of copper are recommended. Slightly longer protection from infection is provided by sulfur spray residues, of which potassium sulfide made up at the rate of 1 pound to 50 gallons of water is the most satisfactory. Bordeaux 1-1-50 leaves a slight residue which may require wiping the cucumbers before they are packed, while potassium sulfide at the rate recommended leaves none. Aside from this fact the use of either copper or potassium sulfide should be influenced by its compatibility with insecticides recommended for controlling insects and red spider.

Bordeaux mixture should be prepared as follows:

As many pounds of bluestone as there are gallons of water are suspended in a sack in the upper surface of the water in a wooden barrel. When the crystals are completely dissolved each gallon will contain 1 pound of bluestone. Similarly, in a second barrel lump or granulated lime is slaked in water. Slaking should proceed slowly with the addition of water as needed. After the lime is slaked, the container is filled with water so that the mixture contains 1 pound of lime to each gallon of water. Hydrated lime may be substituted if lump lime cannot be obtained. Chemically hydrated lime is considered the best, but if plasterer's or finishing lime is used it should be soaked in water over night. One pound of chemically hydrated lime, or 1½ pounds of finishing lime will be required for each gallon of water. In the making of Bordeaux 1-1-50, one gallon of stock lime water is drawn after agitating the mixture thoroughly and poured through a strainer into the spray tank containing 30-40 gallons of water. While the agitator is running, 1 gallon of stock bluestone solution is added. Water is then added to bring the liquid up to 50 gallons. If larger or smaller quantities of spray are desired, proportionate amounts of stock solution must be used. Separate pails should be used for drawing from the stock liquids and a wooden pail should be used for the bluestone. The stock solutions will keep indefinitely but in order that the original concentration of one pound of material to 1 gallon of water is maintained, the barrels should be kept covered.

Commercial copper preparations may be substituted for freshly prepared Bordeaux but they should not be diluted according to directions accompanying the package since these are not applicable to hothouse plants. One pound of bluestone present in Bordeaux 1-1-50 contains about 25 per cent of copper. Each package of copper fungicide bears a statement giving the percentage of copper present in the contents. To determine the amount of material required for making 50 gallons of spray containing as much copper as is present in Bordeaux 1-1-50, divide 25 by the per cent of copper indicated on the pack-

age. Thus, if the label reads "Active ingredient—Copper—12.5%", the quantity of that material to use should be 25/12.5 or 2 pounds in 50 gallons of water.

Combination Treatments

The effective control of different pests on cucumber vines may involve the use of several insecticides and fungicides. Alone, these materials can be used with safety but in combination or when following one another at short intervals, some of these same treatments may cause severe injury to the vines.

Under certain conditions, previously discussed, it is advisable to combat cucumber powdery mildew with copper sprays. These sprays leave a copper residue on the leaves which causes severe burning of cucumber foliage when reacted upon by hydrocyanic acid gas generated from sodium or calcium cyanide. Fumigation with this gas for the control of plant lice, thrips, or white fly, therefore, should always be made before spraying with copper fungicides; otherwise these pests should be combated with nicotine fumes or sprays.

The highly refined white mineral oil emulsion which effectively controls the red spider is not so toxic to plant lice and thrips as is desirable. However, concentrated nicotine solutions, the standard insecticides used for the control of these pests, can be safely mixed with it. When lice or thrips are present with red spider, the addition of one pint of 40 per cent nicotine sulfate or 40 per cent free nicotine liquid in 100 gallons of diluted highly refined white mineral oil emulsion, or 1¼ teaspoonful in a gallon, will control all of these pests. In fact, this combination spray is one of the best insecticides known for use on greenhouse cucumber vines.

If, in addition, mildew is present, Bordeaux mixture or other copper sprays may be safely mixed with the oil-nicotine spray or with the oil spray. The addition of Bordeaux mixture to the oil spray greatly improves its wetting and spreading qualities. This is an advantage for controlling both red spider and powdery mildew. A convenient method for mixing this combination spray is to add one-half gallon of the lubricating oil emulsion to the fully diluted copper spray and agitate until the oil is thoroughly dispersed. The nicotine may be added at any time.

When both powdery mildew and red spider are present, the use of highly refined white mineral oil emulsion and a potassium sulfide spray or high grade sulfur dust, as is recommended for the control of these pests specifically, may cause severe injury to cucumber foliage, especially in warm weather. The oil spray makes the foliage more susceptible to sulfur injury and prohibits the use of dusts containing a large amount of free sulfur or sulfur sprays. Experiments with dusts of low free sulfur content have shown that they may be used safely either before or after the oil spray, and, although only mildly fungicidal to mildew, if the sulfur content is 10 per cent or less, they will control the fungus during bright warm weather. In milder weather sulfur dusts containing 15 and 20 per cent free sulfur have given good control. In cool, damp weather when sulfur dust is less effective, and if the use of the oil emulsion is necessary, mildew outbreaks should be suppressed with copper sprays.

Among commercial dusts, Slug Shot, having a free sulfur content of 6 per

cent has been found safe for use on cucumbers which have been sprayed with white mineral oil emulsion. This dust contains other active ingredients which bring the cost up to about 10 cents a pound. A home-made dust of much greater effectiveness and similar safety can be prepared by thoroughly mixing 15 pounds of dusting sulfur with 85 pounds of either 200 mesh gypsum or talc at a cost of about 1¼ cents per pound for materials. The latter dust is preferable, but since a commercial sulfur dust of this composition is not obtainable, its preparation at home is recommended.

Summary of Recommendations.

Learn to recognize the greenhouse red spider, the cucumber powdery mildew, and the injury which they inflict.

Prevent the establishment and spread of these pests by practicing repressive measures.

For red spider, spray with a highly refined white mineral oil emulsion which is free from injurious carbolic or cresylic compounds.

For powdery mildew, practice proper methods of ventilation, watering, and heating, and use small amounts of high grade dusting sulfur. In dull, cool weather or if powdery mildew is troublesome on lower sides of leaves, spray with copper fungicides or potassium sulfide.

When both pests are present, spray with a highly refined white mineral oil emulsion and dust with a low "free sulfur content" dust in bright, warm weather. In dull, cool, weather, or if powdery mildew is troublesome on lower sides of leaves, spray with a copper fungicide combined with highly refined white mineral oil emulsion.

Precautions When Using Insecticides and Fungicides.

Do not fumigate with hydrocyanic acid gas as long as there is residue from copper fungicides on the leaves.

Do not spray with highly refined white mineral oil emulsion while there is residue from high "free sulfur content" dusts on the leaves.

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